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Modifying the Technology Acceptance Model to Investigate Behavioural Intention to Use Augmented Reality

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Abstract Online retailers are employing interactive technologies to reduce the risk of online purchases. Augmented reality (AR) serves this aim by placing virtual 3D objects (e.g., new furniture) into the consumers' homes. This study investigates the consumer's acceptance of AR applications via a modified Technology Acceptance Model (TAM). Also, we examined the effect of products associated with either high or low financial risk on the relationship between perceived usefulness and behavioural intention. We conducted a single case study with a field between-subject design. The results confirmed the relationships in the modified TAM. In particular, enjoyment had both a direct and indirect positive effect on the behaviour intention of consumers to use the AR app in the future. However, product type did not have a significant effect.

Keywords Augmented reality (AR) · Technology acceptance model (TAM) · Product type

1 Introduction

Augmented reality applications (AR apps) can enhance the consumer experience by merging highly customizable digital content with the touch-and-feel quality of the physical environment. For instance, consumers can place a virtual 3D sofa in their living room and try in real-time if the sofa fits in their room, which can reduce the risk of online purchase and deliver better shopping value for consumers (Dacko, 2017). Retailers have been quick to catch on the added value of AR, which has led

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to an overall increase in investment and implementation of AR in online shopping (PerkinsCoie, 2018). While the innovative nature of AR can help an online retailer to stand out, if the AR technology is not developed in a way that is useful for the consumers, then they might not use it again. The current study helps AR developers in this area by gaining information about the mechanisms that underlie the consumer's intention to adopt AR.

AR studies have employed the Technology Acceptance Model (TAM; cf. Davis, 1989) to understand what drives consumers' intention to use the technology. Four main factors have been established to affect the consumer's behavioural intention to use AR—perceived usefulness, perceived ease of use, perceived enjoyment, and perceived informativeness (Kim & Forsythe, 2008; Rese et al., 2017). The current study extends previous findings in the following ways.

First, previous research has been conducted in laboratory settings. Thus, the consumers' feedback has been restricted to their experience in a not-so-realistic setting (i.e., a lab room). To this point, the current study adopts a more ecologically valid approach by conducting the experimental sessions in participants' homes.

Second, perceived enjoyment has been considered separately as a factor impacting directly perceived usefulness (Rese et al., 2017) and also a factor that has a direct effect on behavioural intention (Kim & Forsythe, 2008). It is unknown, however, whether both ideas about the role of perceived enjoyment may be accurate at the same time. This knowledge can provide insight into the applicability of the (modified) TAM in the context of AR. Moreover, knowledge about the role of perceived enjoyment may be useful in developing future AR apps in this area.

Finally, while previous studies have focused on the experience of the consumer and its effect on their intention to use AR (Dey et al., 2018), this study also investigates the effect of external factors (i.e., product type). In particular, in evaluating products using an AR app, the stakes are higher for high-risk products than for low-risk products. This might imply that app's perceived usefulness has a direct effect on the user's behavioural intention to use the app in the future. All proposed relationships are visualised in Fig. 1.

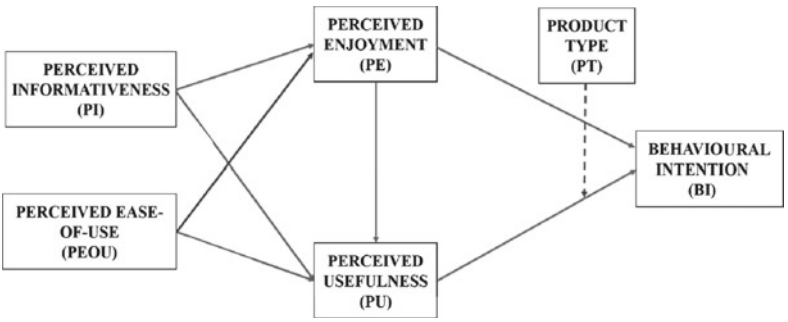

Fig. 1 The modified TAM model illustrating the hypothesized relationships between product type, perceived informativeness, perceived enjoyment, perceived usefulness, perceived ease of use and behavioural intention

2 Theory and Hypotheses

A meta-analysis of studies using the TAM model concludes that TAM is a valid and robust predictive model (Legris et al., 2003). Furthermore, because of its simplicity and parsimony, the model was chosen as the base theoretical model for the current study. TAM is built on Fishbein and Ajzen's theory of reasoned action (TRA), which explains how the individuals' intentions to behave in a certain way are correlated with their attitudes towards the behaviour and beliefs in the form of subjective norm (Ajzen, 1991). Thus, the model's purpose is to predict what features (i.e., variables) influence consumers' intentions to use innovative technology in the future.

The original TAM illustrates that consumers' behavioural intention to use technology is influenced by its *perceived usefulness* (i.e., "the degree to which a person believes that using a particular system would enhance his or her job performance") (Davis, 1989, p. 320). Rese et al. (2017) provided support for this relationship in the context of AR apps. However, their study was conducted in a strictly controlled lab environment. Acknowledging that these kinds of AR apps are purposefully designed to be used by customers in their homes, we tested this effect in a field experiment.

H1. Perceived usefulness has a direct positive effect on behavioural intention.

Furthermore, studies have illustrated that the perceived usefulness of the technology can be influenced by both hedonic (i.e., aim to provide a fun experience for the user) and utilitarian (i.e., aim to support users in fulfilling their goals) factors (Rese et al., 2017). Therefore, the current research will modify the original TAM model by including two variables: *perceived enjoyment* (hedonic) and *perceived informativeness* (utilitarian). Perceived enjoyment is to what degree the consumer believes the technology is playful, entertaining, and satisfies the need "for escapism, diversion, aesthetic enjoyment, or emotional release" (Ducoffe, 1996, p. 23). In a series of lab experiments, Rese et al. (2017) showed that perceived enjoyment was a strong determinant of the perceived usefulness of AR applications. Thus, we expect to find the same relationship in the current field study.

H2. Perceived enjoyment has a direct positive effect on perceived usefulness.

Additionally, Olsson et al. (2012) and Rese et al. (2017) have shown that higher *perceived informativeness* results in higher perceived usefulness of AR apps. Perceived informativeness is to what degree the consumer believes that the technology provides them with relevant and useful information about the product. The effect of perceived informativeness on the perceived usefulness of AR shopping apps, could be due to the nature of those apps. More specifically, AR shopping apps aim to provide customers with relevant information about the product that they consider buying. We suggest that if the app is perceived as giving appropriate and applicable information about the products, the consumers will not merely perceive the app as more useful, but will also enjoy using the app more.

H3. Perceived informativeness has a direct positive effect on (a) perceived usefulness and (b) perceived enjoyment.

Furthermore, Davis suggested that "ease of use operates through usefulness" (Davis, 1989, p. 332). *Perceived ease of use* is "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989, p. 320). Indeed, Rese et al. (2017) and Brito et al. (2018) have shown that higher perceived ease of use of AR apps is predictive of higher perceived usefulness. Furthermore, research has established a correlation between perceived ease of use and perceived enjoyment (Kim & Forsythe, 2008; Rese et al., 2017). The rationale is that systems that are perceived as easier to use are more likely to be perceived as enjoyable (Teo & Chia, 2018).

H4. Perceived ease of use has a direct positive effect on (a) perceived usefulness and (b) perceived enjoyment.

Not only does AR give additional information about products, but at the same time, it offers hedonic value (Olsson et al., 2012, p. 296). Research on trends of traditional online shopping has revealed that perceived enjoyment has a strong positive effect on behavioural intention to use the online platform in the future (Cheema et al., 2013). Furthermore, it could be that perceived enjoyment also has a direct positive effect on the behaviour intention of consumers to use AR apps.

H5. Perceived enjoyment has a direct positive effect on behavioural intention.

Previous AR studies based on TAM have mostly focused on the experience of consumers and its effect on their intention to use AR (Dey et al., 2018). However, external factors, such as what products the technology is used for, have not been investigated. It is essential to consider this factor because different products might carry a different amount of risk when purchased online. According to Pristiwa et al. (2017), perceived risk can influence consumer's behaviour regarding the online platform they are shopping from. A major type of risk that impacts the consumer's behaviour is the financial risk (Thakur & Srivastava, 2015).

AR can be viewed as a tool that decreases the consumer's perceived financial risk during online shopping because it offers additional visual information about the product (Rese et al., 2017). Research has shown that financial risk is related to the risk of losing money through a purchase decision (Derbaix, 1983; Horton, 1976; Sweeney et al., 1999). Indeed, financial risk is correlated with price. For instance, if the price of a given product is higher, then the perceived financial risk is also higher. Financial risk has been pointed out by previous research as one of the most significant features of the overall perceived risk in shopping (see e.g., Kaplan et al., 1974; Stone & Grønhaug, 1993). To counterbalance this risk, an increasing number of retailers are integrating AR into their online shops as it can function as risk insurance. Indeed, it is for this reason that it is of the utmost importance that the app does a good job in terms of usefulness. This is expected to be particularly the case with high-risk products because the potential losses then are higher in case the app would prove useless.

H6. The positive relationship between perceived usefulness and behavioural intention is stronger for high-risk products than for low-risk products.

3 Methodology

3.1 Study Design

The design of a field experiment was chosen because the environmental factors of a home (e.g., space configuration) needed to be present naturally. This improved the ecological validity of the results because the AR app used as a stimulus is developed for consumers to use at their houses. Participants were divided into two groups: low-risk group (n = 48)—participants had to place low-risk products that cost between €10–€30 in their room, and high-risk group (n = 44)—participants had to place high-risk products (€100–€300) in their room.

3.2 Participants

Data were gathered from 100 students. Eight of the participants were excluded from the analyses as they did not use the correct stimuli. Thus, the analysis is based on data from 92 participants ($n_{female} = 69$, $M_{age} = 23$, $SD_{age} = 4.40$). Additionally, none of the participants have used the IKEA Place app before. Participants were divided into two groups: (1) low-risk group (n = 48)—participants had to place low-risk products in their room and (2) high-risk group (n = 44)—participants had to place high-risk products in their room.

3.3 Stimulus Material

All participants used the AR smartphone app IKEA Place. The app was chosen because it has a simple design and does not send distracting messages (Rese et al., 2017). Participants could browse through the IKEA catalogue and tap on an item. Then, the floor and walls of the room were scanned by the camera phone, and a virtual object was placed in the physical space. Then, the item could be moved to the preferred location and/or rotated (Fig. 2).

A *Favourites* list was created in the app (Fig. 3). The list included eight furniture products. Four of the products were low-risk (Fig. 3a), and the other four were high-risk (Fig. 3b). The product s were chosen so that they correspond to each other. For instance, a cheap wardrobe in the low-risk group corresponded to an expensive wardrobe in the high-risk group.

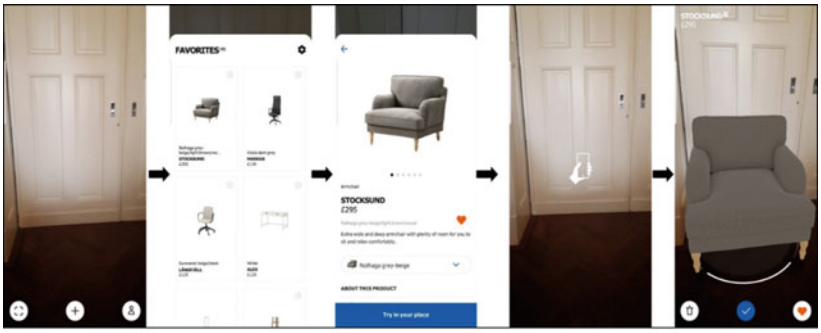

Fig. 2 Sample visualization of the use of the IKEA Place app. From right to left: **a** The app is opened, and the phone camera is pointed towards the desired location in the room; **b** Participants choose an item; **c** Participants view details (i.e., price) of the object and tap on the "Try in your place tab"; **d** The app scans the room; **e** The object is placed in the scanned place

Fig. 3 **a** The four low-risk visual stimuli used in the research; **b** The four high-risk visual stimuli used in the research

3.4 Procedure

The procedure started with a visit from the experimenter in the participant's home. Prior to this, participants were asked to clear a wall in their homes (i.e., move around their furniture), to use the app without any obstacles. The visit started with a short information and consent form procedure. Then, participants were given a list of instructions and used the IKEA Place App to place four furniture objects in a room in their home. To not interfere with the participants' experience, the researcher was not present in the room. After finishing the task, participants were asked to fill in an online questionnaire (10 min). Finally, participants were debriefed and reimbursed.

3.5 Variables and Measurement Instrument

We measured variables with an online questionnaire. The full version of the questionnaire can be found in Appendix 1 at https://bit.ly/3eYwXId. First, we asked participants for their age, gender identification, and previous use of the IKEA Place app. Then, we measured the four independent variables, one dependent variable, and four control variables. The questionnaire was based on validated and reliable tools explained below.

Perceived informativeness (PI). The first independent variable was measured with four questions used in the Rese et al. (2017) study. The questions included statements such as: "The IKEA app provides detailed information about the furniture."; "The IKEA app provides the complete information about the furniture.". Participants had to show their level of agreement with each of the statements on a 7-point Likert scale, anchored from 1 (strongly disagree) to 7 (strongly agree). The PI scale ($M = 5.21$; $SD = 1.02$) was reliable ($\alpha = .866$).

Perceived enjoyment (PE). The second independent variable was measured with four questions used in the Rese et al. (2017) study (Cronbach's $\alpha = .892$). The questions included statements such as: "Using the IKEA app is really fun."; "The scan function and its elements are a nice feature.". Participants had to show their level of agreement with each of the statements on the previously mentioned 7-point Likert scale. The PE scale ($M = 5.38$; $SD = .96$) was reliable ($\alpha = .89$).

Perceived ease of use (PEOU). The third independent variable was measured with four questions used in the Rese et al. (2017) study. The questions included statements such as: "I found the IKEA app to be very easy to use."; "The IKEA app was intuitive to use." Participants had to show their level of agreement with each of the statements on the same 7- point Likert scale. The PEOU scale ($M = 5.01$; $SD = 1.25$) was reliable ($\alpha = .89$). *Perceived usefulness (PU).* The fourth independent variable was measured with four questions used in the Rese et al. (2017) study. The questions included statements such as: "For me, the IKEA app has great value."; "The IKEA app provides beautiful interior design ideas.". Participants had to show their level of

agreement with each of the statements on the same 7-point Likert scale. The PEOU scale ($M = 4.81$; $SD = 1.25$) was reliable ($\alpha = .91$).

Behavioural intention (BI). The dependent variable was measured with five questions used in the Rese et al. (2017) study. The questions included statements such as: "If I were to buy furniture in the future, I would: …download or use the IKEA app immediately; …give the IKEA app priority over the printed catalogue.". Participants had to show their level of agreement with each of the statements on the same 7-point Likert scale. The BI scale ($M = 4.41$; $SD = 1.28$) was reliable ($\alpha = .91$).

Affinity with interior design (AID). This control variable is defined as a participants' enduring involvement with interior design. We expect that since the IKEA Place app involves making an interior design decision about one's own home, participants who have a higher interest in the topic might perceive the app as more enjoyable and informative. The variable was measured with The Enduring Involvement Scale (Bruner, 2015). Participants had to use a 7-point scale to give a numerical expression of their opinion on statements such as: "I find Interior Design is: "1 = unimportant/7 = important"; "1 = uninteresting/7 = interesting". The AID scale ($M = 5.40$; $SD = .98$) was reliable ($\alpha = .94$).

Attitude towards the company (ATC). Since the AR application that participants used during the study was related to the IKEA brand, we suspected that if a participant has an extreme attitude towards IKEA, this will influence how enjoyable and useful they will find the app. Therefore, we measured participants' attitudes towards the company using the Attitude Toward the Company Scale (Bruner, 2015).Participants had to use a 7-point scale to express their opinion towards IKEA on items such as: "1 = Negative/7 = Positive"; "1 = Unfavourable/7 = Favourable". The ATC scale ($M = 5.29$; $SD = 1.06$) was reliable ($\alpha = .84$).

Technological innovativeness (TI). We expected that people who are more technologically innovative would find the app more informative and useful because they are more inclined to use new technology as a reliable source of information. Therefore, we used the Technological Involvement Scale as included in the Bruner scales manual (2015). The questions included statements such as: "Other people come to me for advice on new technologies."; "In general, I am among the first in my circle of friends to acquire new technology when it appears.". Participants had to show their level of agreement with each of the statements on a 7-point Likert scale anchored from 1 (strongly disagree) to 7 (strongly agree). The TI scale ($M = 4.21$; $SD = 1.04$) was reliable ($\alpha = .91$).

Finally, the last question checked whether the experimental task was completed correctly. We asked participants to choose pictures of the objects that they used the app for. As previously mentioned, participants who failed to use the correct stimuli ($N = 8$) were excluded from the data analysis.

4 Results

First, we examined the presence of outliers, prevalence, and patterns of missing values, and normal distribution of the data. We concluded that the data included five outlier values (>$M + 3SD$)—one in perceived enjoyment, two in perceived usefulness, one in perceived ease of use, and one in attitude towards the company. To decide whether to exclude the outliers from the main analysis we followed Sweet and Grace-Martin (2012) guidelines which state that outliers are deleted only if: (1) they are a wrong entry or (2) they are some special cases isolated from a common phenomenon the analysis. Both guidelines that are listed above do not apply to the current data set and analysis. First, because the outliers are still entered on the same pre-defined scale with a limited fixed range. Second, because not all outliers came from the same participants in the same product group. Thus, we cannot say with confidence that some common unforeseen circumstances have resulted in these outliers and therefore they do represent the tested sample. Moreover, additional analyses showed that exclusion of the outliers did not alter the study findings substantially. Below, we report the data analysis and results of the data set with outliers.

Second, we checked if the control variables are correlated with any of the main variables. Age was not significantly correlated with any of the main variables. Affinity towards interior design had a significant positive association with perceived usefulness (r (92) = .20, $p < .05$) and behavioural intention (r (92) = .21, $p < .05$). Attitude towards the company had a significant positive association with perceived informativeness (r (92) = .29, $p < .01$), perceived usefulness (r (92) = .21, $p < .05$), perceived enjoyment (r (92) = .29, $p < .05$), perceived ease of use (r (92) = .21, $p < .05$) and behavioural intention (r (92) = .22, $p < .05$). Finally, technological innovativeness had a significant positive association with perceived usefulness (r (92) = .22, $p <$ .05).

Finally, we used linear regressions controlling for age, affinity towards interior design, attitude towards the company and technological innovativeness. The results of the hypotheses testing are summarized in Fig. 4. The analysis showed that the effect of perceived usefulness on behavioural intention was significant ($\beta = .35$, SE = .09, $p < .001$), as well as the effect of perceived enjoyment on perceived usefulness ($\beta = .24$, $SE = .11$, $p < .05$). Next, the effect of perceived ease of use on perceived enjoyment was not significant ($\beta = .15$, $SE = .09$, $p = .13$). Perceived ease of use had significant positive effect on perceived usefulness ($\beta = .23$, $SE = 2.39$, $p < .05$). Also, the effect of perceived informativeness on perceived usefulness was significant ($\beta = .23$, $SE = 2.18$, $p < .05$) as well as the effect of perceived informativeness on perceived enjoyment ($\beta = .33$, $SE = .10$, $p < .01$). Lastly, perceived enjoyment had a direct positive effect on behavioural intention ($\beta = .44$, $SE = .09$, $p < .001$) but product type was not a significant moderator of the relationship between perceived usefulness and behavioural intention ($\beta = .05$, $SE = .03$, $p = .49$).

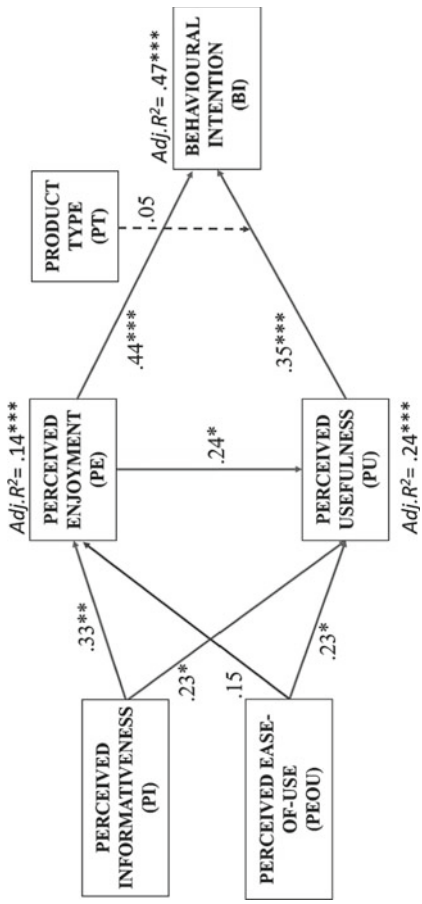

Fig. 4 The modified TAM model illustrating the results of the hypothesized relationships between product type, perceived enjoyment, perceived informativeness, perceived usefulness, perceived ease of use and behavioural intention (N = 92)

5 Discussion

The main findings of the study are: (1) the results from earlier studies using the (modified) TAM model can be replicated in a study with a field design; (2) perceived enjoyment is a factor that has both a (strong) direct influence and a weaker indirect influence on behavioural intention (3) product type does not moderate the impact of perceived usefulness on the intention to adopt AR apps.

Regarding the modeled TAM relationships, Rese et al. (2017) have shown that perceived usefulness has a direct effect on behavioural intention. Also, Kim and Forsythe (2008) have considered its direct influence on behavioural intention. The current study, however, shows that both of these effects exist simultaneously. However, perceived enjoyment had a stronger direct effect on behavioural intention than perceived usefulness. Furthermore, perceived enjoyment also directly influenced perceived usefulness. These two findings illustrate that perceived enjoyment could be a more important aspect of retail AR apps than previously thought. Thus, future studies can invest in efforts to replicate these results to establish a clearer idea of the role of perceived enjoyment in the experience of AR technology in retail.

Contrary to our expectations, we did not find an effect of product type on the relationship between perceived usefulness and behavioural intention. The insignificant difference between product groups could be attributed to our study sample, which consisted of students. The general lack of financial opportunity to buy the relatively expensive products might have resulted in participants in the high-risk group not experiencing a financial risk of the product (Bagga & Bhatt, 2013; O'Liery, 2017). As a result, the low-risk versus high-risk factor did not have the expected effect. Future studies in different samples could shed light on the value of this explanation.

Most importantly, the current study tested the TAM model in field settings that were not controlled by the researcher. This is in contrast with most previous research on TAM, which has been conducted in controlled and artificial settings (i.e., a research lab) (Brito et al., 2018; Rese et al., 2017). By making use of a more realistic setting (i.e., the participants' home), the current study added to the ecological validity of previous research findings. Thus, by taking all the previous experimental evidence together with the current results, this study's outcomes suggest that the TAM model is a valid and generalizable theoretical model for studying the acceptance of AR in 'real-life' settings.

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